

### Oceanic Circulation

THE letters of Prof. Everett and Mr. Wallace (*NATURE*, Aug. 22) establish one point which must go a good way towards the settlement of the disputed question of the cause of oceanic circulation, viz., that in order to maintain the bare mechanical possibility of the gravitation theory, it is necessary to assume that water is so nearly quite devoid of molecular resistance to motion that, were it not for the impediments offered by continents, water flowing from a low to a comparatively high latitude would be revolving eastwards with the velocity of an arrow. In the southern hemisphere, where continents are "few and far between," and where a comparatively open channel exists through which the waters may circulate round the globe at any velocity without much impediment, this rapid general eastward motion of the ocean ought to be developed to a large extent. But the fact remains that no such motion has ever been observed. Dr. Carpenter says:—"It is well known to navigators that there is a perceptible 'set' of warm surface water in all the southern oceans towards the Antarctic Pole; this 'set' being so decided in one part of the Southern Indian Ocean as to be compared by Capt. Maury to the Gulf Stream of the North Atlantic" (*NATURE*, March 24, 1870). This general motion of the water in the southern hemisphere Dr. Carpenter adduces as strong evidence in favour of his theory. But why is not the "set" as much to the east as to the south? If the presence of the Antarctic continent does not hinder the motion of the water polewards, why should the presence of the continents of Australia or the southern portion of South America hinder the motion of the water eastward, seeing that rotation performs about 1,500 times more work in deflecting the water eastward than the difference of specific gravity performs in impelling the water southward? The very fact that the water does not turn to the east but moves straight towards the Antarctic continent, shows that the waters must be impelled by a force immensely greater than that derived from difference of specific gravity, because it must be greater than that derived from rotation, or else the "set" would be as much to the east as to the south. There are, it is true, a few currents in the southern hemisphere with an eastern motion, but these the advocates of the gravitation theory would call "mere surface drifts produced by the winds." Besides the majority of the currents in that hemisphere move in wrong directions to be explained either by difference of specific gravity or by rotation.

That the explanation given by Prof. Everett and Mr. Wallace does not even touch the difficulty which besets the gravitation theory, far less removes it, will, I trust, be further evident from the following considerations, viz., a current in mid-ocean a thousand miles from land, flowing from a low to a higher latitude, has its eastward motion due to rotation as effectually checked and diminished as though it abutted against a continent. This retardation cannot be attributed to the presence of continents, for it occurs equally the same whether the land be one thousand, two thousand, or five thousand miles to the east. It is the resistance of the molecules of the water through which the current moves that destroys the eastward motion. No matter how slow the current may flow polewards, by the time the water reaches, say latitude 60°, each pound has lost at least 9,000 of the

eastward velocity which it possessed when it left the equatorial regions. It is a matter of indifference in what way this energy is consumed by the molecules of the water, whether it be in friction in rotation, or whether it becomes potential in the raised water through which the current flows; for in either case it is the resistance offered by the stationary molecules which causes the moving molecules to lose their velocity. The resistance being molecular, that which holds true of eastward holds equally true of westward motion. This is proved also by the fact that a current flowing from a higher to a lower latitude has its westerly motion due to rotation as effectually checked and diminished as a current flowing from a lower to a higher latitude has of easterly. And what holds true of motion to the east or to the west, holds equally true of motion to the south or north, for there is no reason why the resistance should be less in one direction than in another.

It therefore follows that it is impossible that 6 foot-pounds could impel a pound of water from the Equator to latitude  $60^\circ$  against the molecular resistances to its motion, when during the passage of the pound of water it requires 9,000 foot-pounds to overcome the resistance to the easterly deflections which take place. Or if the molecular resistance of water be so infinitesimal that 6 foot-pounds is sufficient, then it is impossible that molecular resistance could consume 9,000 foot-pounds during the easterly deflection which takes place.

I respectfully submit that this is a clear and obvious demonstration of the mechanical impossibility of the gravitation theory of oceanic circulation.

Prof. Everett says that Mr. Ferrel's argument from the tides is quite conclusive in showing that the forces arising from difference of temperature are of sufficient magnitude to keep up an oceanic circulation. If Prof. Everett, like Mr. Ferrel, really supposes that a slope produced by the moon is the same as one produced by difference of density, and that the process by which the water tends to regain its level is the same in both cases, I am not surprised he should consider Mr. Ferrel's argument conclusive.

I beg to refer Mr. Wallace to the *Philosophical Magazine* for October 1871, p. 244, for an explanation of the fallacy of Dr. Carpenter's famous experiment to which he alludes.

Had the present state of my health permitted, I should have entered somewhat more fully into some of the above points, but in the meantime I must withdraw from any further discussion.

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